FIG. 1

Spa
Control
Panel

```
   46
12:38
SPA-TEC
```
48

12

System
Interconnection
Panel

14

110/220 VAC
Input

16

Temp 2 (spa) 20

Temp 1 (heating
Ph Probe elemen

22   30

| Pump | Heater | Blower | Light |

24   26   28   30

FIG. 2

Microcomputer — 10

— 42

EPROM Memory — 44

RAM Memory — 32

RTC — 34

Display Intf — 38

Display — 40

39

Digital In (Process) — 74

Digital Out (Process) — 58

Analog In — 36

Signal Cond — 39

Keyboard Intf — 56

Keyboard — 48

pH Probe — 22
Maintenance Mode
110/260 — 16
Spare
Spare
System interconne panel

Heater — 26
Pump1 — 24
Pump 2 (high)
Blower — 28
Spa light — 30

Temp1 — 20
Temp2 — 20
Ph — 22
Spare

FIG. 3

110/220 VAC
16

Access Door
Safety Interlock

GFCI
Protection
64

66
Power
Supply

To
Spa
Control
Panel
C 12

Triacs
62

Opto-
Isolators

60 [zero crossing
circuitry]

Field Connection Board
70

Connectors
71

Pump
Motor
(Two Speed)
24

Blower
Motor
28

Heater
Core
26

Spa
Light
72

FIG. 4

```
                              ┌──────────────┐
                              │    Main      │
                              │   Program    │──────  80
                              └──────┬───────┘
                                     │
        ┌──────────────┐             │          ┌──────────────┐
        │  Keyboard    │             │          │     PID      │
  82 ───│  Monitor     │─────────────┼──────────│   Control    │─── 92
        └──────────────┘             │          └──────────────┘
        ┌──────────────┐             │          ┌──────────────┐
        │  Display     │             │          │   Output     │
  84 ───│  Control     │─────────────┼──────────│   Control    │─── 94
        └──────────────┘             │          └──────────────┘
        ┌──────────────┐             │          ┌──────────────┐
        │  Alarm       │             │          │   Input      │
  86 ───│  Control     │─────────────┼──────────│   Scanning   │─── 96
        └──────────────┘             │          └──────────────┘
        ┌──────────────┐             │          ┌──────────────┐
        │  Analog      │             │          │     Ph       │
  88 ───│  Conversion  │─────────────┼──────────│  Algorithm   │─── 98
        └──────────────┘             │          └──────────────┘
        ┌──────────────┐             │
        │  RTC         │             │
  90 ───│  Control     │─────────────┘
        └──────────────┘
```

FIG. 5

FIG. 6 - Overall flow or Control

~100

reset

+------------------------+
: initialization : ~102
+------------------------+

                              ------ interrupts enabled ------

                              timer ~104   powerfail ~108
                              interrupt   interrupt

+-----------------+ ~104
: main program :   +----------+ ~110   +----------+ ~112
+-----------------+   : poll :   : system :
                                    : inputs :   : shutdown :
                                    +----------+   +----------+

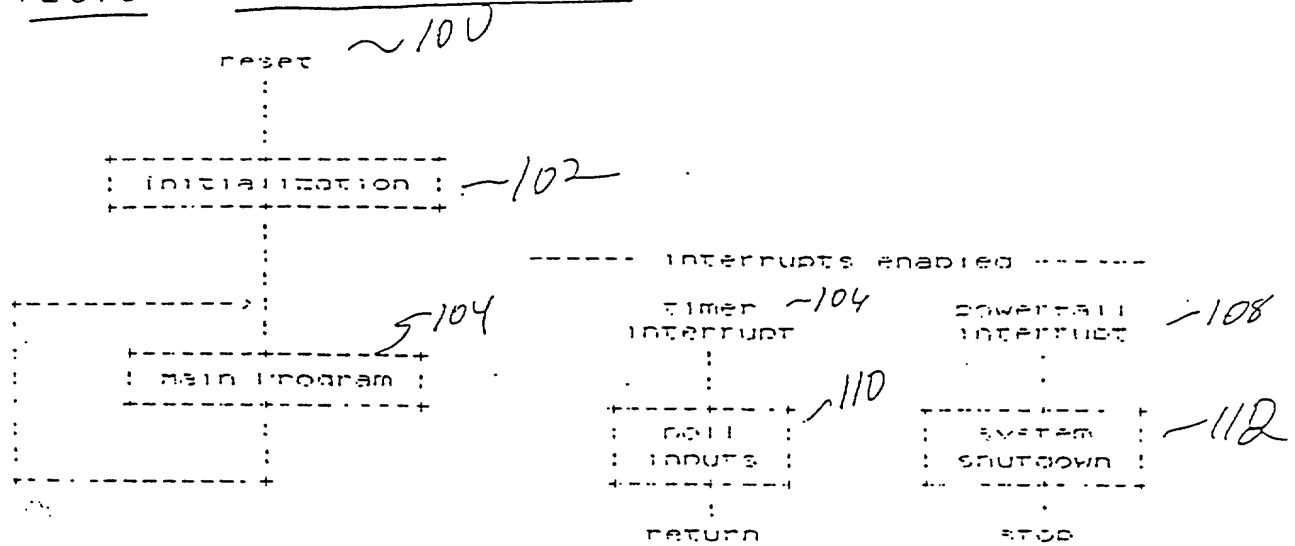   return   stop

FIG.7

$Temp_F$ = Desired Temperature of Spa Water

$Temp_1$ = Temperature at First Sensor (S_1)

$Temp_2$ = Temperature at Second Sensor (S_2)

$Temp_\Delta$ = $Temp_1 - Temp_2$

Δ_L = Limit of acceptable temperature difference (plus or minus).

```
                                    ┌─────────────┐
                          ─────────▶│ Read Temp₁  │
                         │          │ and Temp₂   │
                         │          └─────────────┘
                         │                 │
                         │          ┌─────────────┐
                         │          │ Calculate   │
                         │          │ Temp∆       │
                         │          └─────────────┘
                         │                 │
          ┌──────────────┐      ╱───────────────╲      ┌────────────────────┐
          │ operate      │  No ╱  Temp∆          ╲ Yes │ Deactivate Heater(26)│
          │ Heater(26)   │─────│      ≥  ∆L      │─────│                    │
          └──────────────┘      ╲               ╱      └────────────────────┘
                                 ╲─────────────╱                │
                                                      ┌────────────────────┐
                                                      │ Signal Display(4b) │
                                                      └────────────────────┘
```

FIG. 8

Read
Auto Volt Detect

IS
System
110
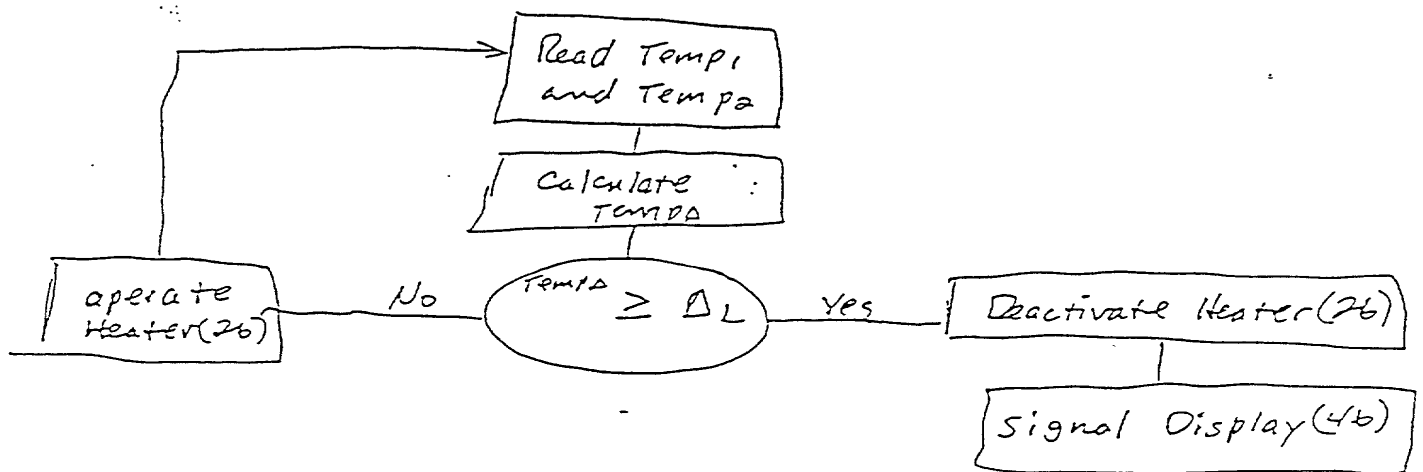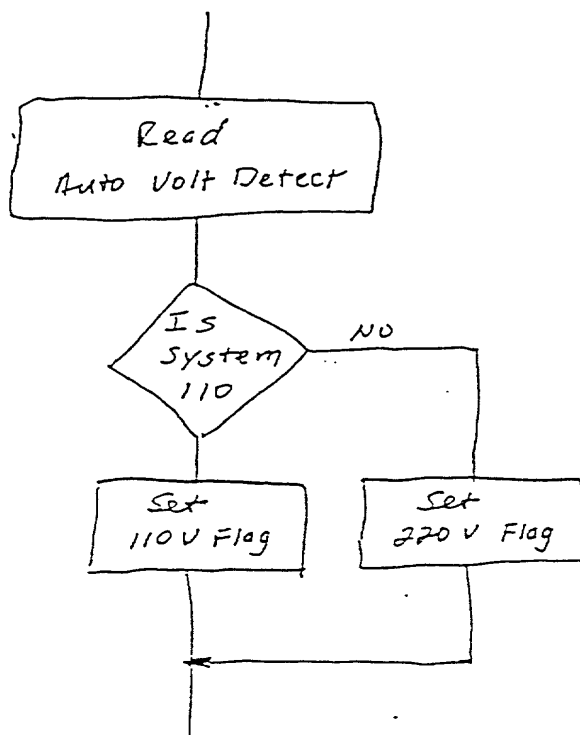
NO

Set
110V Flag

Set
220V Flag

FIG. 9

Rate = Rate of Heating

$Rate_{AV}$ = Rate of Heating (average)

$Temp_F$ = Desired temperature of Spa water

$Temp_I$ = Initial temperature of Spa water

$Temp_\Delta$ = $Temp_F - Temp_I$

$Time_I$ = Time (initial)

$Time_F$ = Time (final)

$Time_\Delta$ = $Time_F - Time_I$

```
        ┌──────────────────┐
        │   Read Temp_I     │
        └──────────────────┘
                 │
        ┌──────────────────┐
        │   Read Time_I     │
        └──────────────────┘
                 │
        ┌──────────────────┐          ┌────────────┐
        │ Activate Heater(86)│◄─────── │  Continue  │
        └──────────────────┘          └────────────┘
                 │                            ▲
             ╭────────╮      No               │
            (  Temp_F  )───────────────────────┘
             ╰────────╯
                 │ Yes
        ┌──────────────────┐
        │    Calculate     │
        │     Time_Δ       │
        └──────────────────┘
                 │
        ┌──────────────────┐
        │    Calculate     │
        │    Rate_AV       │
        └──────────────────┘
                 │
        ┌──────────────────┐
        │   Store          │
        │   Rate           │
        └──────────────────┘
```
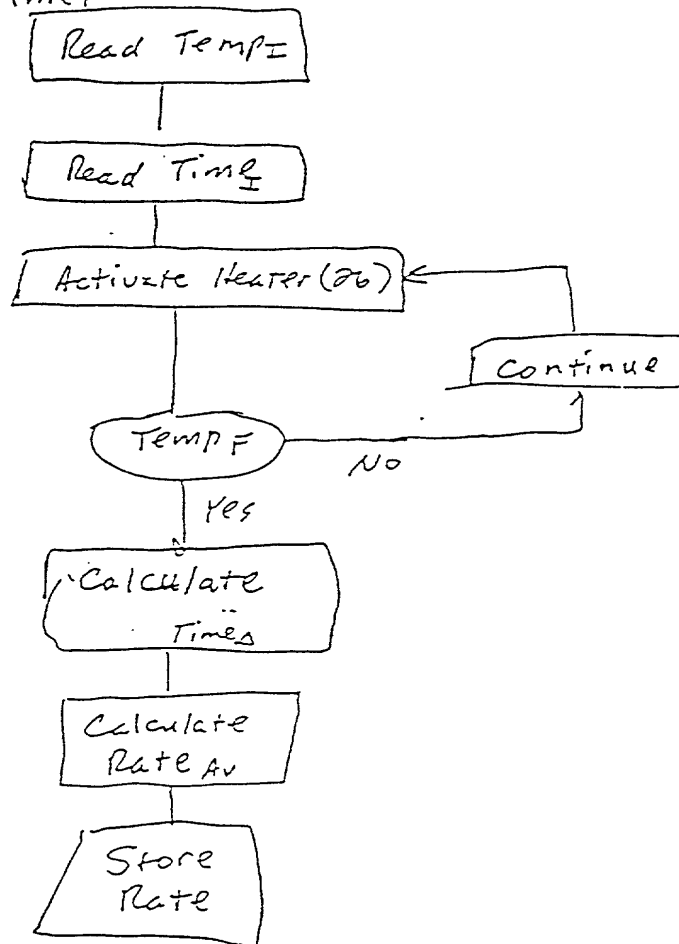
FIG 10

$Temp_I$ = Initial temperature of Spa water

$Temp_F$ = Final temperature (desired) of Spa water

$Temp_\Delta$ = $Temp_F - Temp_I$

Rate = Rate of Heating

$Rate_{AV}$ = Rate of Heating (average)

$Time_I$ = Initial time
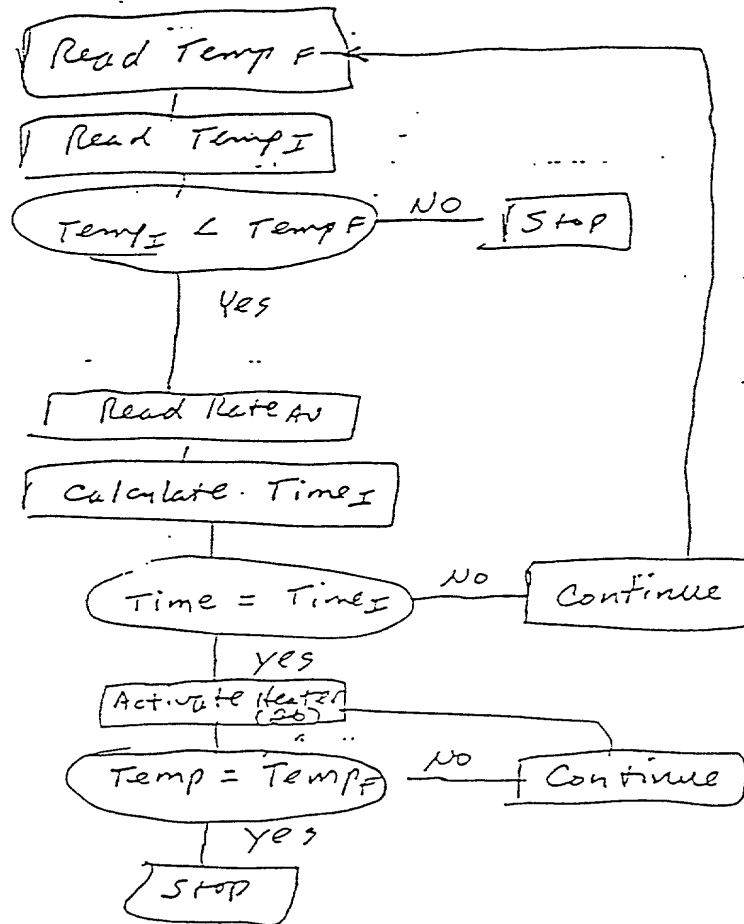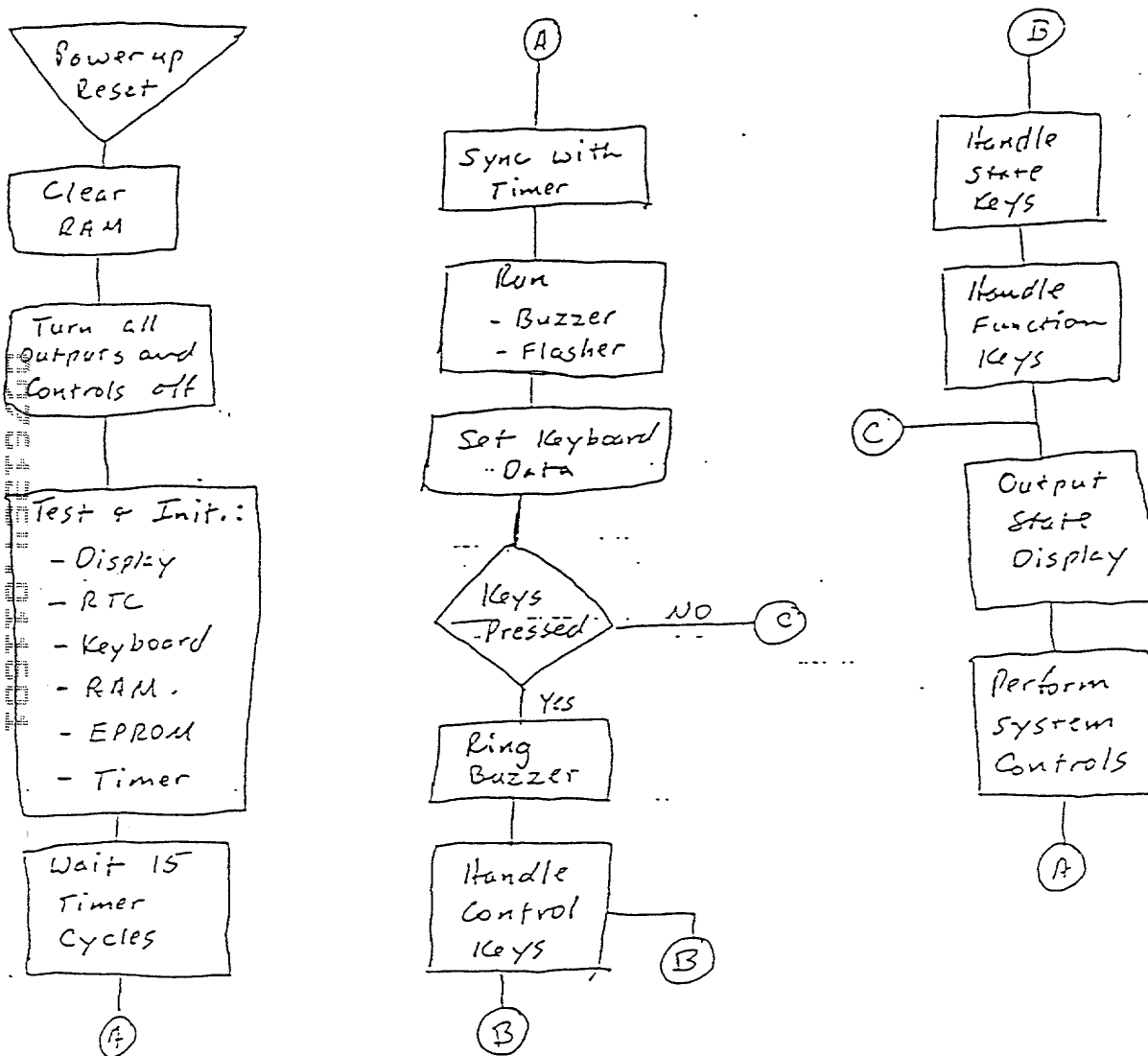
$Time_F$ = Final time

$Time_\Delta$ = $Time_F - Time_I$

```
          ┌──────────────────┐
          │  Read Temp F      │──────────────────┐
          └──────────────────┘                   │
          ┌──────────────────┐                   │
          │  Read Temp I      │                   │
          └──────────────────┘                   │
          ╭──────────────────╮   NO  ┌───────┐   │
          │  Temp I < Temp F  │─────── │ Stop │   │
          ╰──────────────────╯        └───────┘   │
                  │ Yes                           │
          ┌──────────────────┐                   │
          │  Read Rate AV     │                   │
          └──────────────────┘                   │
          ┌──────────────────┐                   │
          │ Calculate Time I  │                   │
          └──────────────────┘                   │
          ╭──────────────────╮  NO  ┌──────────┐ │
          │  Time = Time I    │───── │ Continue │─┘
          ╰──────────────────╯      └──────────┘
                  │ yes
          ┌──────────────────┐
          │ Activate Heater   │
          │   (20)            │─────────────┐
          └──────────────────┘             │
          ╭──────────────────╮  NO  ┌──────────┐
          │  Temp = Temp F    │───── │ Continue │
          ╰──────────────────╯      └──────────┘
                  │ yes
          ┌──────────────────┐
          │      STOP         │
          └──────────────────┘
```

FIG. 11

Power up Reset

Clear RAM

Turn all Outputs and Controls off

Test & Init.:
- Display
- RTC
- Keyboard
- RAM.
- EPROM
- Timer

Wait 15 Timer Cycles

(A)

(A)

Sync with Timer

Run
- Buzzer
- Flasher

Set Keyboard Data

Keys Pressed? — NO → (C)

Yes

Ring Buzzer

Handle Control Keys → (B)

(B)

(B)

Handle State Keys

Handle Function Keys

(C) —

Output State Display

Perform System Controls

(A)

FIG. 12

Timer Interrupt

Poll Keyboard

Poll rte

Read Analog input

Convert to Eng. units

Done

FIG. 13

Powerfail

Write Ext RAM to EEROM

Turn off all controls

Display Fail

(E) —

Latch Powerfail

(D)

(D)

Powerfail? — Yes → (E)

NO

Simulate Reset